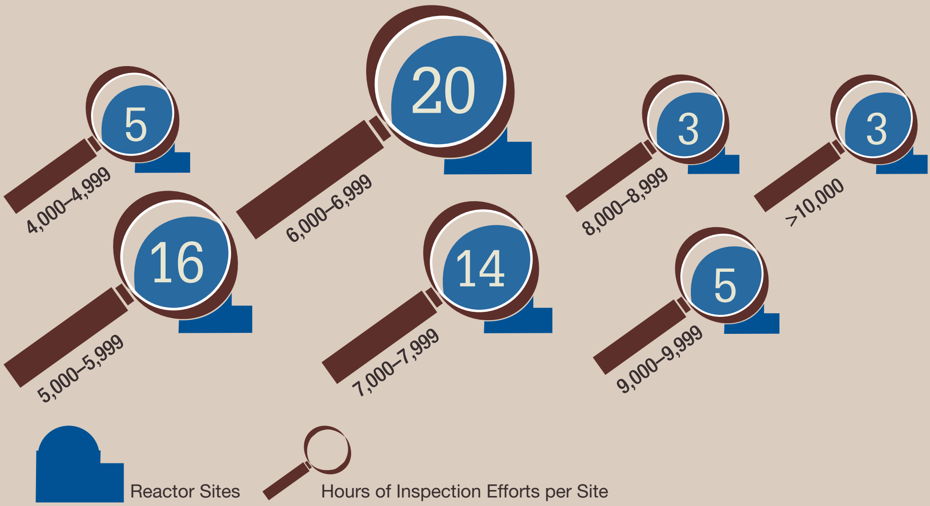
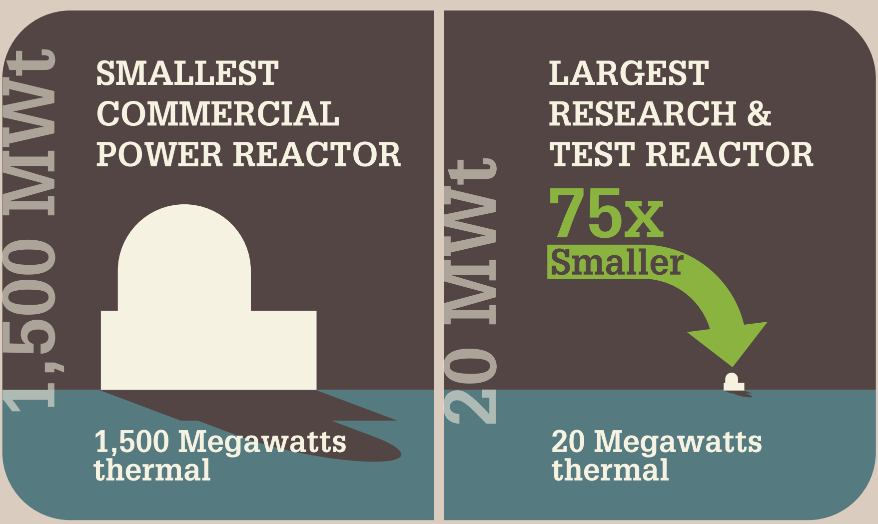
Nuclear Reactors

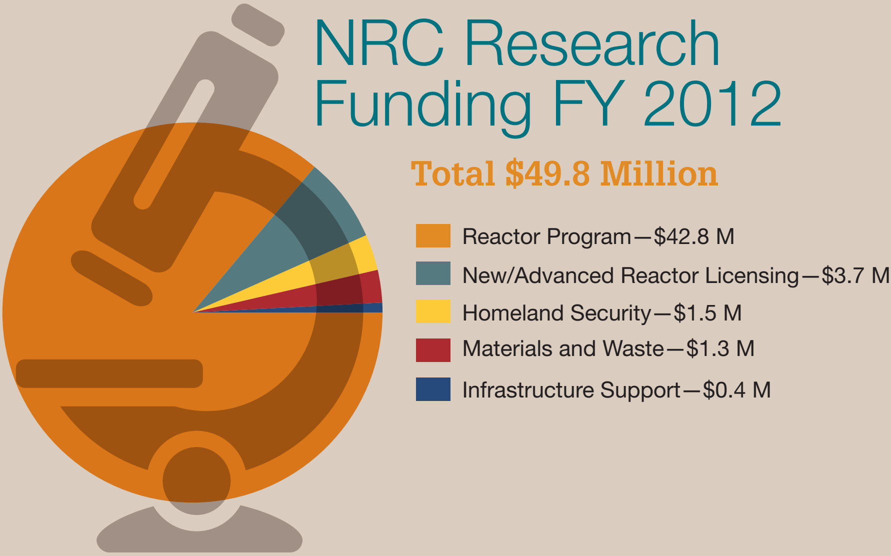
NRC Reactor Inspection Efforts



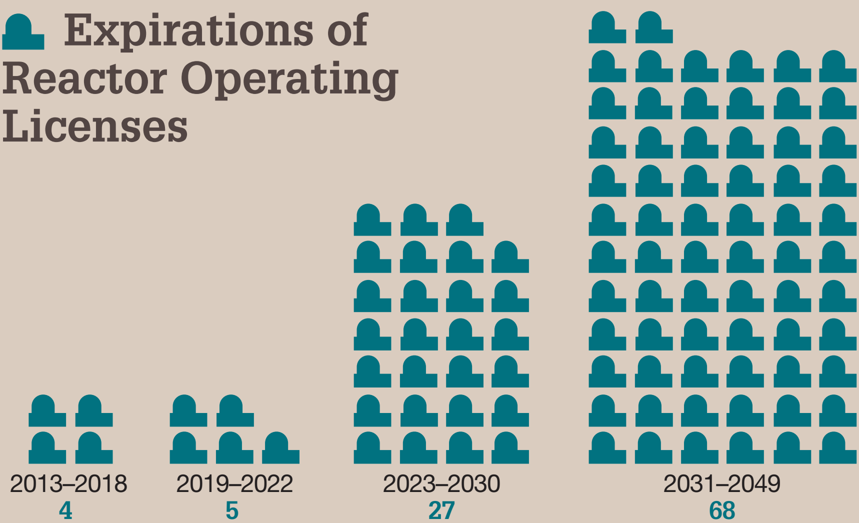


NRC Research Funding FY 2012

Total $49.8 Million



Expirations of Reactor Operating Licenses



U.S. Commercial Nuclear Power Reactors

As of August 2012, 104 commercial nuclear power reactors were licensed to operate in 31 States (see Figure 14). These reactors have the following characteristics:

- 4 different reactor vendors
- 26 operating companies
- 80 different designs
- 65 sites

See Appendix A for a listing of reactors and their general licensing information and Appendix U for Native American Reservations and Trust lands near nuclear power plants.

Diversity

Although there are many similarities, each reactor design can be considered unique. Figure 15 shows a typical pressurized-water reactor (PWR), and Figure 16 shows a typical boiling-water reactor (BWR). Currently there are 35 BWR and 69 PWR reactor designs.

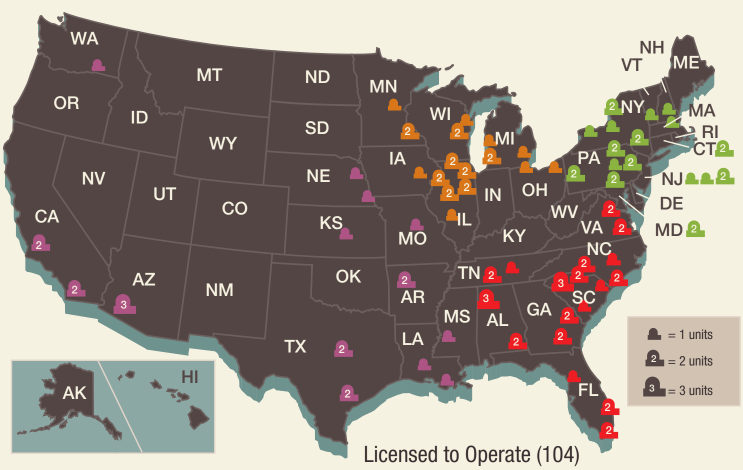
Resident Inspectors

The NRC has at least two full-time inspectors at each nuclear power plant site to ensure that facilities are meeting NRC regulations.

Photo courtesy of Dominion Nuclear Connecticut, Inc.

Millstone Power Station, located in Waterford, CT.

Figure 14. U.S. Operating Commercial Nuclear Power Reactors



Licensed to Operate (104)

REGION I

CONNECTICUT
- Millstone 2 and 3

MARYLAND
- Calvert Cliffs 1 and 2

MASSACHUSETTS
- Pilgrim

NEW HAMPSHIRE
- Seabrook

NEW JERSEY
- Hope Creek
- Oyster Creek
- Salem 1 and 2

NEW YORK
- FitzPatrick
- Ginna
- Indian Point 2 and 3
- Nine Mile Point 1 and 2

PENNSYLVANIA
- Beaver Valley 1 and 2
- Limerick 1 and 2
- Peach Bottom 2 and 3
- Susquehanna 1 and 2
- Three Mile Island 1

VERMONT
- Vermont Yankee

REGION II

ALABAMA
- Browns Ferry 1, 2, and 3
- Farley 1 and 2

FLORIDA
- Crystal River 3
- St. Lucie 1 and 2
- Turkey Point 3 and 4

GEORGIA
- Edwin I. Hatch 1 and 2
- Vogtle 1 and 2

NORTH CAROLINA
- Brunswick 1 and 2
- McGuire 1 and 2
- Harris 1

SOUTH CAROLINA
- Catawba 1 and 2
- Oconee 1, 2, and 3
- Robinson 2
- Summer

TENNESSEE
- Sequoyah 1 and 2
- Watts Bar 1

VIRGINIA
- North Anna 1 and 2
- Surry 1 and 2

REGION III

ILLINOIS
- Braidwood 1 and 2
- Byron 1 and 2
- Clinton
- Dresden 2 and 3
- LaSalle 1 and 2
- Quad Cities 1 and 2

IOWA
- Duane Arnold

MICHIGAN
- Cook 1 and 2
- Fermi 2
- Palisades

MINNESOTA
- Monticello
- Prairie Island 1 and 2

OHIO
- Davis-Besse
- Perry

WISCONSIN
- Kewaunee
- Point Beach 1 and 2

REGION IV

ARKANSAS
- Arkansas Nuclear 1 and 2

ARIZONA
- Palo Verde 1, 2, and 3

CALIFORNIA
- Diablo Canyon 1 and 2
- San Onofre 2 and 3

KANSAS
- Wolf Creek 1

LOUISIANA
- River Bend 1
- Waterford 3

MISSISSIPPI
- Grand Gulf

MISSOURI
- Callaway

NEBRASKA
- Cooper
- Fort Calhoun

TEXAS
- Comanche Peak 1 and 2
- South Texas Project 1 and 2

WASHINGTON
- Columbia

Figure 15. Typical Pressurized-Water Reactor

How Nuclear Reactors Work

In a typical design concept of a commercial PWR, the following process occurs:

1. The core inside the reactor vessel creates heat.
2. Pressurized water in the primary coolant loop carries the heat to the steam generator.
3. Inside the steam generator, heat from the primary coolant loop vaporizes the water in a secondary loop, producing steam.
4. The steamline directs the steam to the main turbine, causing it to turn the turbine generator, which produces electricity.

The unused steam is exhausted to the condenser, where it is condensed into water. The resulting water is pumped out of the condenser with a series of pumps, reheated, and pumped back to the steam generator. The reactor's core contains fuel assemblies that are cooled by water circulated using electrically powered pumps. These pumps and other operating systems in the plant receive their power from the electrical grid. If offsite power is lost, emergency cooling water is supplied by other pumps, which can be powered by onsite diesel generators. Other safety systems, such as the containment cooling system, also need electric power. PWRs contain between 150–200 fuel assemblies.

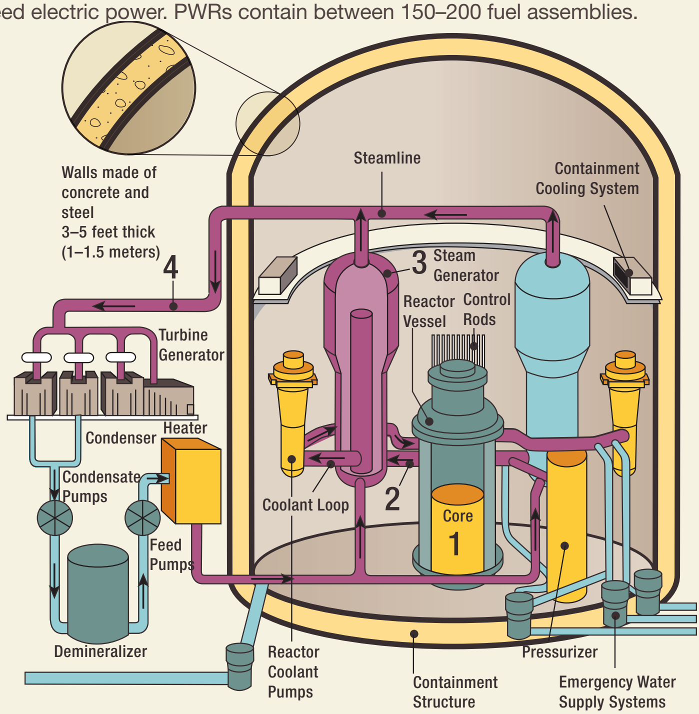


Figure 16. Typical Boiling-Water Reactor

How Nuclear Reactors Work

In a typical design concept of a commercial BWR, the following process occurs:

1. The core inside the reactor vessel creates heat.
2. A steam-water mixture is produced when very pure water (reactor coolant) moves upward through the core, absorbing heat.
3. The steam-water mixture leaves the top of the core and enters the two stages of moisture separation where water droplets are removed before the steam is allowed to enter the steamline.
4. The steamline directs the steam to the main turbine, causing it to turn the turbine generator, which produces electricity.

The unused steam is exhausted to the condenser, where it is condensed into water. The resulting water is pumped out of the condenser with a series of pumps, reheated, and pumped back to the reactor vessel. The reactor's core contains fuel assemblies that are cooled by water circulated using electrically powered pumps. These pumps and other operating systems in the plant receive their power from the electrical grid. If offsite power is lost, emergency cooling water is supplied by other pumps, which can be powered by onsite diesel generators. Other safety systems, such as the containment cooling system, also need electric power. BWRs contain between 370–800 fuel assemblies.

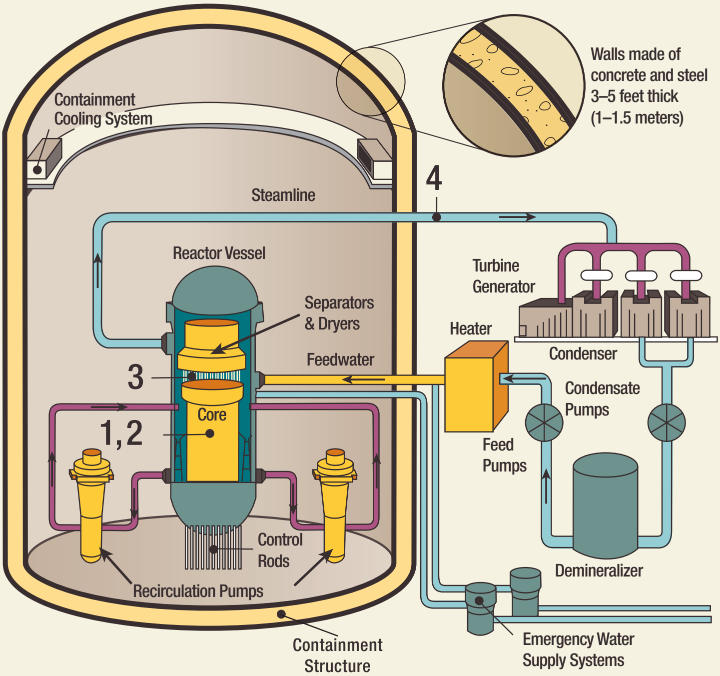
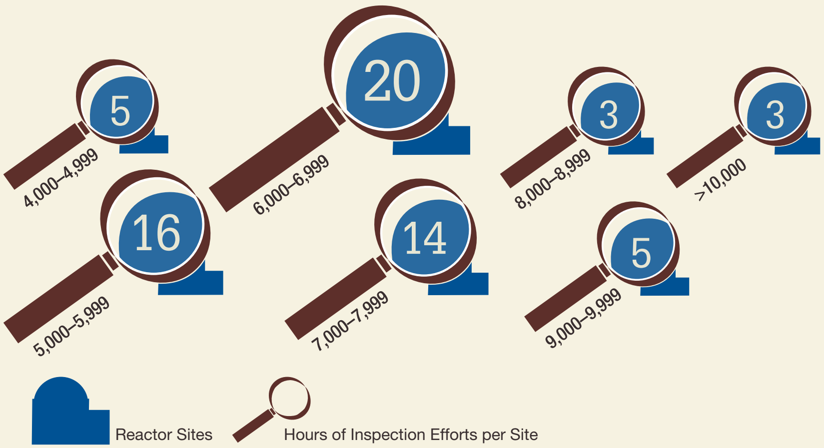


Figure 17. NRC Inspection Effort at Operating Reactors, 2011



Note: Data include Calendar Year (CY) 2011 hours for all activities related to baseline, plant-specific, generic safety issue, and allegation inspections.

* 66 total sites (including Indian Point Units 2 and 3, which are treated as separate sites for inspection effort)

An NRC inspector conducts routine inspections of plant equipment to ensure the plant is meeting NRC regulations.

3

Principal Licensing, Inspection, and Enforcement Activities

The NRC conducts a variety of licensing and inspection activities:

See Appendix B for permanently shut down and decommissioning reactors and Appendix W for significant enforcement actions.

- The NRC is reviewing an operating license application from the Tennessee Valley Authority for the Watts Bar Unit 2 reactor under construction near Spring City, TN.
- Typically, each power reactor licensee requests about 10 separate license changes each year. The NRC completed more than 1,000 separate reviews in FY 2011.
- Currently, there are approximately 4,600 NRC-licensed reactor operators. Each operator must requalify every 2 years and apply for license renewal every 6 years.
- On average, the NRC expended approximately 6,820 hours of inspection-related effort at each operating reactor site during 2011 (see Figure 17).
- The NRC reviews applications for proposed new reactors and is developing an inspection program to oversee construction.
- The NRC reviews approximately 3,000 operating experience items, such as fire protection and access authorization programs, from licensed facilities annually.
- The NRC issues about 15 to 20 escalated enforcement actions per year to operating reactors for violations having a relatively high level of significance with regard to licensed activities affecting public health and safety. The primary enforcement actions, depending on the severity, are notices of violation, civil penalties, and orders.
- The NRC reviews approximately 600 allegations per year; allegations are assertions of inadequacy or impropriety associated with NRC-regulated activities.
- ACRS, an independent body of nuclear, engineering, and safety experts appointed by the Commission, reviews numerous safety issues for existing or proposed reactors and provides independent technical advice to the Commission. ACRS held 11 full Committee meetings and approximately 70 subcommittee meetings during 2011.
- The NRC currently oversees the decommissioning of 14 nuclear power reactors.

Oversight of U.S. Commercial Nuclear Power Reactors

The NRC does not operate nuclear power plants. Rather, it regulates the operation of the Nation's 104 nuclear power plants by establishing regulatory requirements for their design, construction, and operation. To ensure that the plants are operated safely within these requirements, the NRC licenses the plants to operate, licenses the plant operators, establishes technical specifications for the operation of each plant, and inspects plants daily.

Reactor Oversight Process

The NRC provides continuous oversight of plants through its Reactor Oversight Process (ROP) to verify that they are being operated in accordance with NRC rules, regulations, and license requirements. The NRC has full authority to take action to protect public health and safety, up to and including shutting a plant down.

In general terms, the ROP uses both NRC inspection findings and performance indicators from licensees to assess the safety performance and security measures of each plant. There are five levels that range from "fully meeting all safety cornerstone objectives" to "unacceptable performance" (see Figure 19). The ROP recognizes that issues may range from very low to high safety significance, but plants are expected to address all issues effectively. The NRC performs very detailed baseline-level inspections at each plant. If plant problems arise, NRC oversight increases. The agency may perform supplemental inspections and take additional actions to ensure that significant performance issues are addressed. The latest plant-specific inspection findings and performance indicator information can be found on the NRC's Web site (see the Web Link Index).

The ROP takes into account improvements in the performance of the nuclear industry over the past 30 years and improved approaches to inspecting and evaluating the safety performance of NRC-licensed plants. The improvements in plant performance can be attributed both to successful regulatory oversight and to efforts within the nuclear industry. The ROP is described on the NRC's Web site and in NUREG-1649, Revision 4, "Reactor Oversight Process," issued December 2006.

Industry Performance Indicators

In addition to evaluating the performance of each individual plant, the NRC compiles data on overall reactor industry performance using various industry-level performance indicators (see Figure 20).

Figure 18. Day in the Life of an NRC Resident Inspector

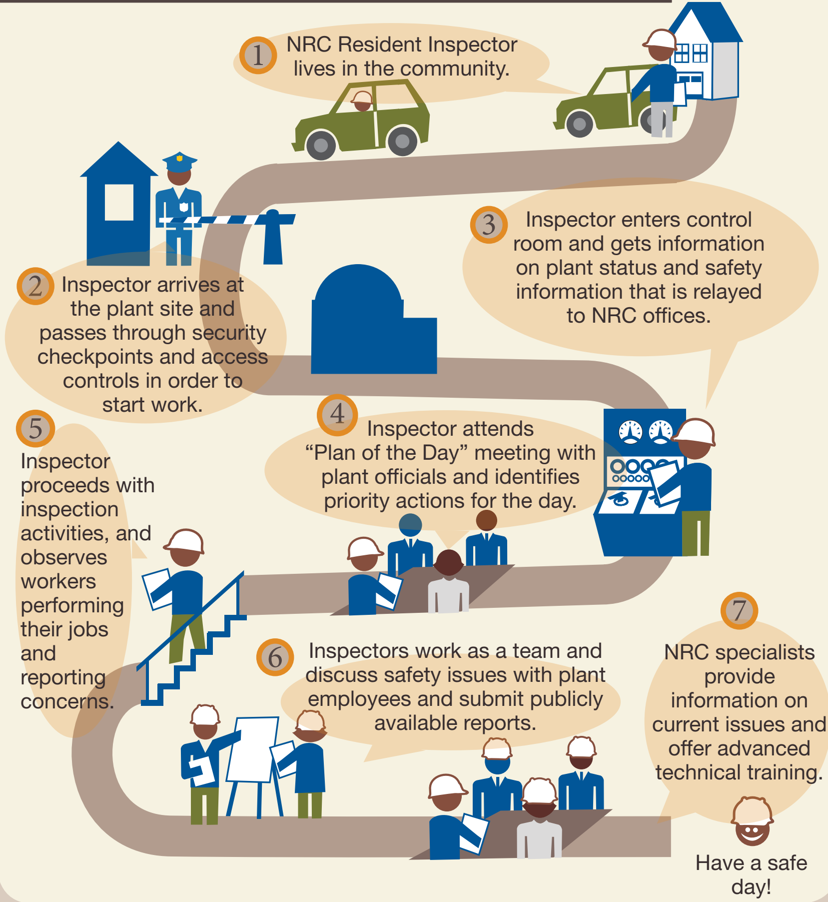


Figure 19. Reactor Oversight Action Matrix Performance Indicators

Performance Indicators

GREEN | WHITE | YELLOW | RED

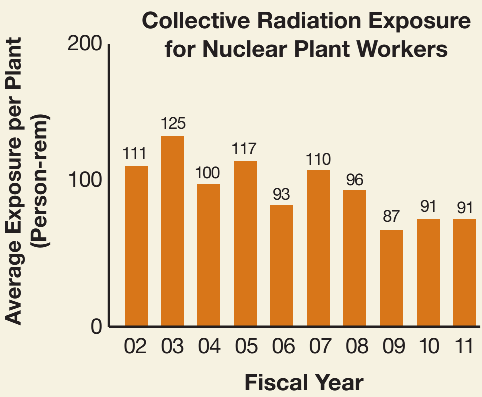
Increasing Safety Significance →

Inspection Findings

GREEN | WHITE | YELLOW | RED

Increasing Safety Significance →

Figure 20. Industry Performance Indicators: FYs 2002–2011 Averages



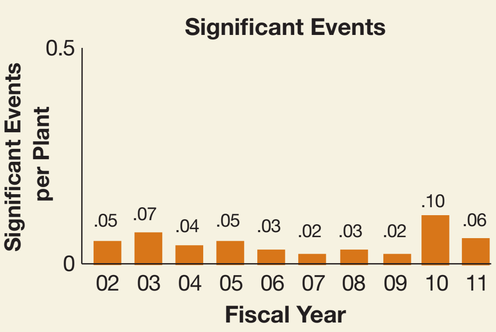
This indicator monitors the total radiation dose accumulated by plant personnel.

Further Explanation:
In 2011, those workers receiving a measurable dose of radiation received an average of about 0.1 rem. For comparison purposes, the average U.S. citizen receives 0.3 rem of radiation each year from natural sources (i.e., the everyday environment). See the definition of "exposure" in the Glossary.

Note: Data represent annual industry averages, with plants in extended shutdown excluded. Data are rounded for display purposes. These data may differ slightly from previously published data as a result of refinements in data quality.

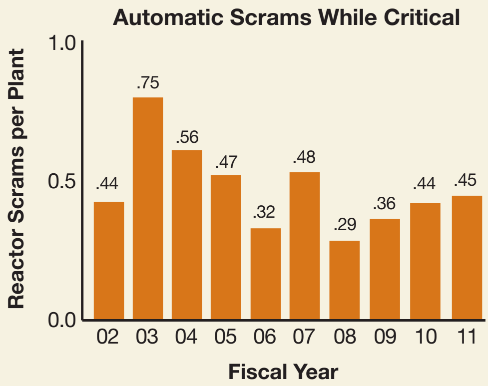
Source: Licensee data as compiled by the NRC

Figure 20. Industry Performance Indicators: FYs 2002–2011 Averages (continued)



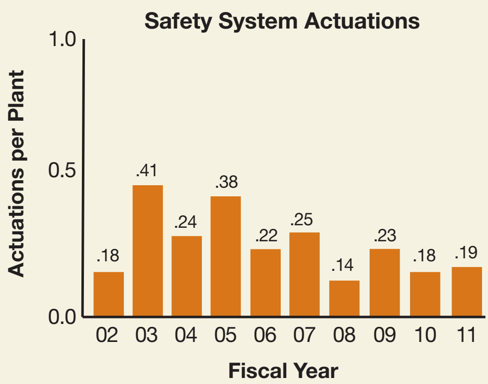
Significant events are events that meet specific NRC criteria, for example, degradation of safety equipment, a sudden reactor shutdown with complications, or an unexpected response to a sudden degradation of fuel or pressure boundaries. The NRC staff identifies significant events through detailed screening and evaluation of operating experience.

Figure 20. Industry Performance Indicators: FYs 2002–2011 Averages (continued)



A reactor is said to be "critical" when it achieves a self-sustaining nuclear chain reaction, such as when the reactor is operating. The sudden shutting down of a nuclear reactor by the rapid insertion of control rods, either automatically or manually by the reactor operator, is referred to as a "scram." This indicator measures the number of unplanned automatic scrams that occurred while the reactor was critical.

Figure 20. Industry Performance Indicators: FYs 2002–2011 Averages (continued)



Safety system actuations are certain manual or automatic actions taken to start emergency core cooling systems or emergency power systems. These systems are specifically designed to either remove heat from the reactor fuel rods if the normal core cooling system fails or provide emergency electrical power if the normal electrical systems fail.

Reactor License Renewal

Based on the Atomic Energy Act of 1954, as amended, the NRC issues licenses for commercial power reactors to operate for 40 years. Under current regulations, licensees may renew their licenses for up to 20 years. Economic and antitrust considerations, not limitations of nuclear technology, determined the original 40-year term for reactor licenses. However, because of this selected time period, some systems, structures, and components may have been engineered on the basis of an expected 40-year service life.

See Appendix F and G for power reactors operating licenses by year issued and expired

As of June 2012, over 80 percent of the 104 licensed reactor units either have received or are under review for license renewal (31 units operate under their original license) . Of these, 73 units (at 44 sites) have received renewed licenses (see Figure 21). Figure 22 illustrates the years of commercial operation of operating power reactors. Figure 23 shows the expiration dates of operating commercial nuclear licenses. The decision to seek license renewal rests entirely with nuclear power plant owners and typically is based on the plant's economic situation and on whether it can meet NRC requirements.

The license renewal review process provides continued assurance that the current licensing basis will maintain an acceptable level of safety for the period of extended operation. The NRC will renew a license only if it determines that a currently operating plant will continue to maintain the required level of safety. Over the plant's life, this level of safety is enhanced through maintenance of the plant and its licensing basis, with appropriate adjustments to address new information from industry operating experience. The NRC regulations establish clear requirements for license renewal to ensure safe plant operation for extended plant life, as codified in 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants." Environmental protection requirements for license renewal are contained in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

The review of a renewal application proceeds along two paths—one for the review of safety issues and the other for environmental issues (see Figure 24). An applicant must provide the NRC with an evaluation that addresses the technical aspects of plant aging and describes the ways those effects will be managed. The applicant must also prepare for and evaluate the potential impact on the environment if the plant operates for up to an additional 20 years.

Figure 21. License Renewals Granted for Operating Nuclear Power Reactors

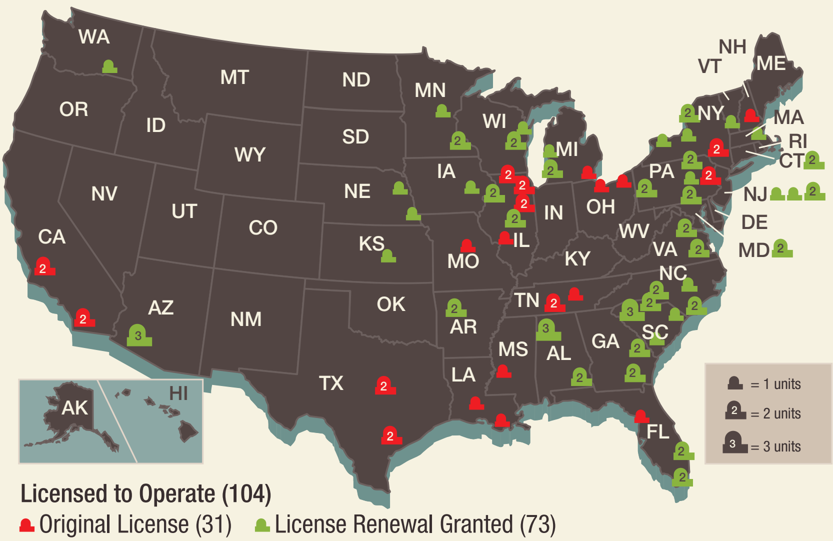
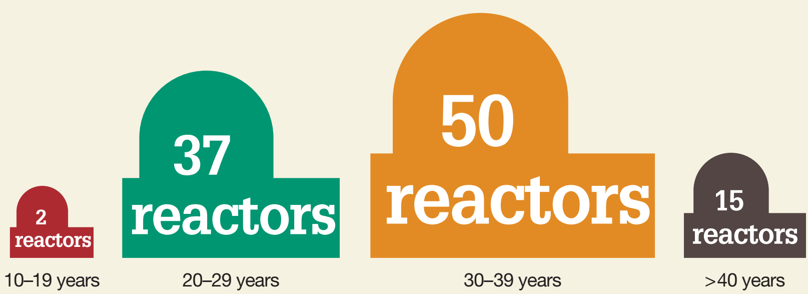


Figure 22. U.S. Commercial Nuclear Power Reactors—Years of Operation by the End of 2012



Note: Ages have been rounded up to the end of the year.

Figure 23. U.S. Commercial Nuclear Power Reactor Operating Licenses—Expiration by Year

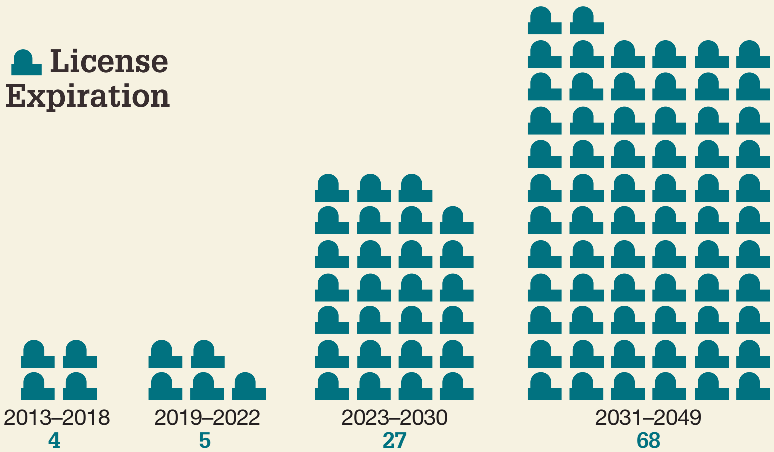
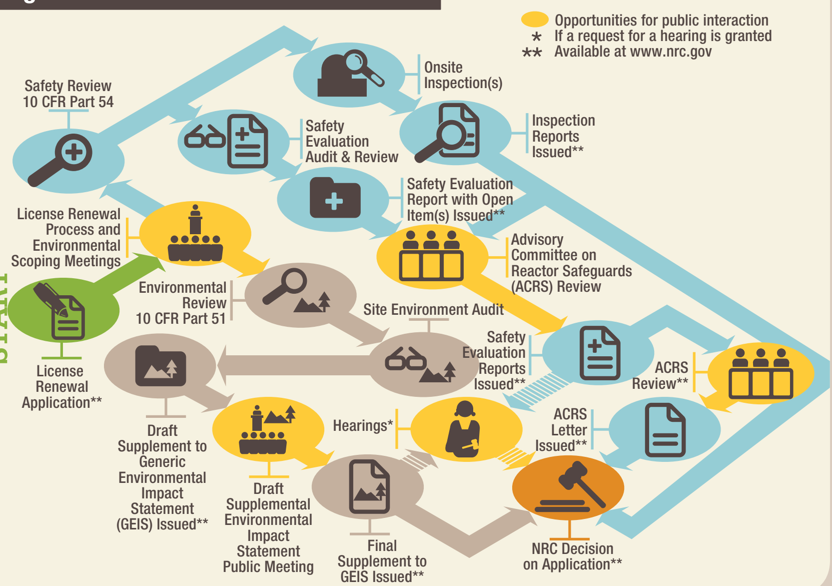


Figure 24. License Renewal Process



The NRC reviews the application and verifies the safety evaluation through onsite inspections.

Public Involvement

Public participation is an important part of the license renewal process. Members of the public have several opportunities to question how aging will be managed during the period of extended operation. The NRC makes available to the public information provided by the applicant and holds several public meetings. The agency fully documents its technical and environmental review results and makes them publicly available. In addition, ACRS holds public meetings to discuss technical or safety issues related to plant designs or a particular plant or site. Stakeholder concerns may be litigated in an adjudicatory hearing if any party that would be affected requests a hearing and submits an admissible contention. For more information, visit the NRC Web site (see the Web Link Index).

Research and Test Reactors

Nuclear research and test reactors (RTRs) are designed and used for research, testing, and education in nuclear engineering, physics, chemistry, biology, anthropology, medicine, materials sciences, and related fields. These reactors do not produce commercial electricity, but they help prepare people for nuclear-related careers in the fields of nuclear engineering, electric power, national defense, health services, research, and education.

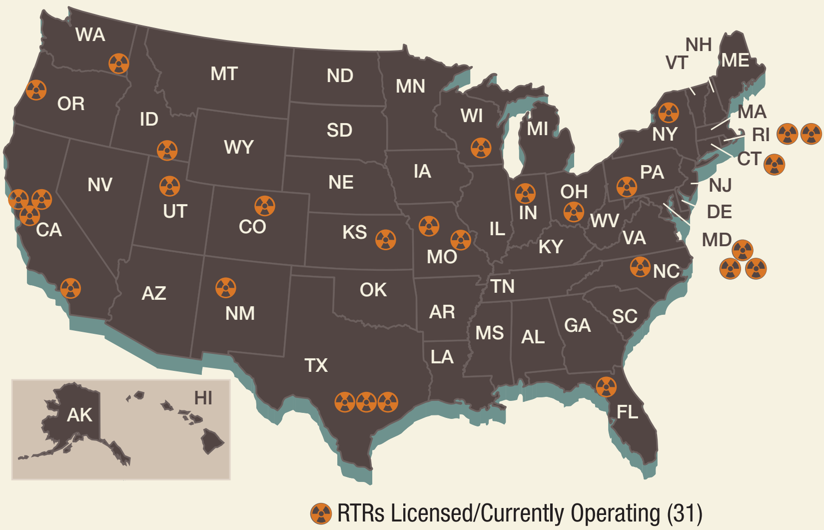
See Appendix I for a list of the 31 operating RTRs regulated by the NRC and Appendix J for a list of the 11 RTRs regulated by the NRC that are in the process of decommissioning.

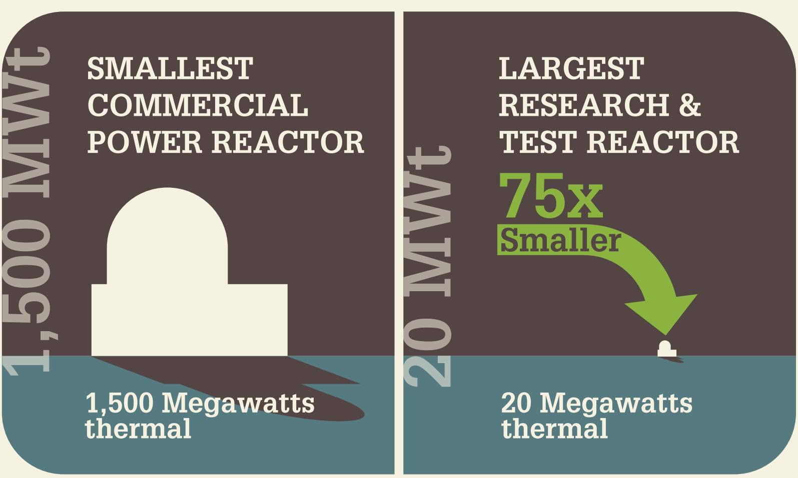
The largest U.S. RTR (at 20 megawatts thermal) (MWt) is 75 times smaller than the smallest U.S. commercial power nuclear reactor (at 1,500 MWt). There are 42 licensed RTRs:

- 31 RTRs operating in 21 States (see Figure 25)
- 11 RTRs shut down and in various stages of decommissioning

RTRs licensed to operate at a power level of 2 MWt or greater are inspected annually. RTRs licensed to operate at power levels below 2 MWt are inspected every 2 years. Since 1958, 83 licensed RTRs have been decommissioned.

Figure 25. U.S. Nuclear Research and Test Reactors





Principal Licensing and Inspection Activities

The NRC's principal licensing and inspection activities related to RTRs include the following:

- licensing the 31 operating RTRs, including license renewals and license amendments;
- licensing approximately 100 RTR operators;
- requalifying operators' license before renewal; and
- conducting approximately 36 RTR inspections each year.

New Commercial Nuclear Power Reactor Licensing

The NRC is reviewing new reactor applications using a licensing process that substantially improved the system used through the 1990s (see Figure 26). In early 2012, the NRC issued the first combined construction and operating licenses (called a combined license or COL) under the new licensing process.

The NRC expects to review approximately 10 additional COL applications for approximately 16 new reactors over the next several years and has in place the infrastructure and staff to support the necessary technical work (see Figure 27 and the Web Link Index). The Fukushima lessons learned are being included in the design certification, COL, and ESP reviews.

Construction and Operating License Applications

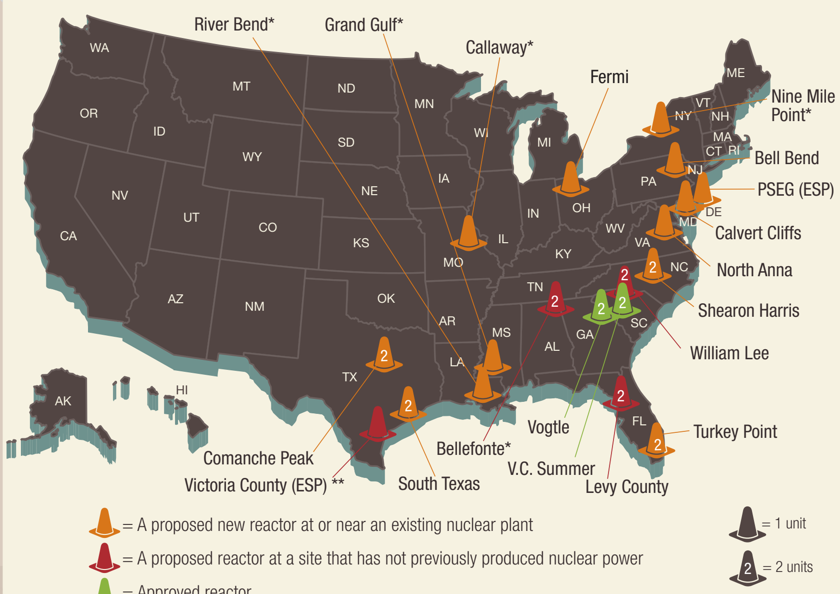
As of June 2012, the NRC has received 18 COL applications for 28 new reactor units:

- Calvert Cliffs (MD)
- South Texas Project (TX)
- Bellefonte (AL)
- North Anna (VA)
- William States Lee III (SC)
- Shearon Harris (NC)
- Grand Gulf (MS)
- Vogtle (GA)*
- V.C. Summer (SC)*
- Callaway (MO)
- Levy County (FL)
- Victoria County Station (TX)
- Fermi (MI)
- Comanche Peak (TX)
- River Bend (LA)
- Nine Mile Point (NY)
- Bell Bend (PA)
- Turkey Point (FL)

* Approved by the NRC in early 2012

Figure 26. New Reactor Licensing Process

Figure 27. Locations of New Nuclear Power Reactors Applications



* Review suspended ** COL application amended by applicant to ESP on March 25, 2010.
Note: Data is as of June 2012.

Nuclear Reactors

The NRC suspended or cancelled six COL application reviews because of changes in applicant business strategies (Grand Gulf, Callaway, Nine Mile Point, River Bend, Victoria County Station, and Bellefonte).

As of June 2012, the NRC had 10 COL applications for 16 units under active review. Figure 27 shows the locations of the potential new reactor sites. For the current review schedule for reactor licensing applications, consult the NRC public Web site (see the Web Link Index).

Public Involvement

The NRC's new reactor licensing process offers many opportunities for public participation. Before it receives an application, the agency uses public meetings to talk to residents in the community near the location where a proposed new reactor may be built to explain how the NRC reviews an application and how the public may participate in the process. Next, the NRC listens to comments on which factors should be considered in the agency's environmental review of the application. The public may then comment on the NRC's draft environmental evaluation that is posted on the agency's Web site. There is no formal opportunity for public comment on the staff's safety evaluation, but members of the public are welcome to attend public meetings and make comments. In addition, the public is afforded the opportunity to legally challenge a license application through Atomic Safety and Licensing Board hearings that are announced in press releases and posted on the NRC Web site. The NRC has tailored its new reactor licensing activities to review new applications effectively and efficiently without compromising safety.

Early Site Permits

An early site permit (ESP) provides for early resolution of site safety, environmental protection, and emergency preparedness issues independent of a specific nuclear plant review. The ACRS reviews those portions of the ESP application that concern safety. Mandatory adjudicatory hearings associated with the ESPs are conducted after the completion of the NRC staff's technical review.

The NRC has issued ESPs to the following applicants:

- System Energy Resources, Inc. (Entergy), for the Grand Gulf site in Mississippi
- Exelon Generation Company, LLC, for the Clinton site in Illinois
- Dominion Nuclear North Anna, LLC, for the North Anna site in Virginia
- Southern Nuclear Operating Company, for the Vogtle site in Georgia

Table 1. U.S. New Nuclear Power Plant Applications

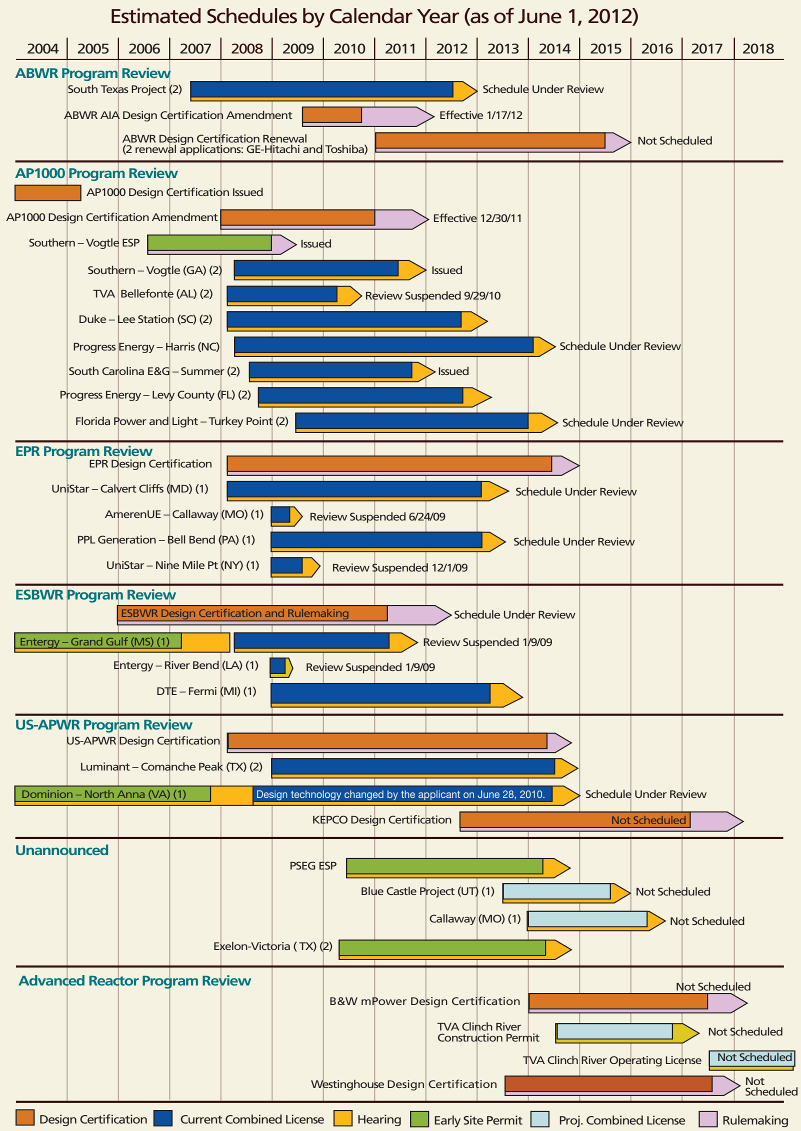
Company (Project/Docket #)	Date of Application	Design	Date Accepted	Site Under Consideration	State	Existing Op. Plant
Calendar Year (CY) 2007 Applications						
NRG Energy (52-012/013)	9/20/07	ABWR	11/29/07	South Texas Project (2 units)	TX	Y
NuStart Energy (52-014/015)	10/30/07	AP1000	1/18/08	Bellefonte (2 units)	AL	N
UNISTAR (52-016)	7/13/07 (Env.), 3/13/08 (Safety)	EPR	1/25/08 6/3/08	Calvert Cliffs (1 unit)	MD	Y
Dominion (52-017)*	11/27/07	US-APWR	1/28/08	North Anna (1 unit)	VA	Y
Duke (52-018/019)	12/13/07	AP1000	2/25/08	William Lee Nuclear Station (2 units)	SC	N
2007 TOTAL NUMBER OF APPLICATIONS = 5 TOTAL NUMBER OF UNITS = 8						
CY 2008 Applications						
Progress Energy (52-022/023)	2/19/08	AP1000	4/17/08	Harris (2 units)	NC	Y
NuStart Energy (52-024)	2/27/08	ESBWR	4/17/08	Grand Gulf (1 unit)	MS	Y
Southern Nuclear Operating Co. (52-025/026)	3/31/08	AP1000	5/30/08	Vogtle (2 units)	GA	Y
South Carolina Electric & Gas (52-027/028)	3/31/08	AP1000	7/31/08	Summer (2 units)	SC	Y
Progress Energy (52-029/030)	7/30/08	AP1000	10/6/08	Levy County (2 units)	FL	N
Detroit Edison (52-033)	9/18/08	ESBWR	11/25/08	Fermi (1 unit)	MI	Y
Luminant Power (52-034/035)	9/19/08	US-APWR	12/2/08	Comanche Peak (2 units)	TX	Y
Entergy (52-036)	9/25/08	ESBWR	12/4/08	River Bend (1 unit)	LA	Y
AmerenUE (52-037)	7/24/08	EPR	12/12/08	Callaway (1 unit)	MO	Y
UNISTAR (52-038)	9/30/08	EPR	12/12/08	Nine Mile Point (1 unit)	NY	Y
PPL Generation (52-039)	10/10/08	EPR	12/19/08	Bell Bend (1 unit)	PA	Y
2008 TOTAL NUMBER OF APPLICATIONS = 11 TOTAL NUMBER OF UNITS = 16						
CY 2009 Applications						
Florida Power & Light Co. (52-040/041)	6/30/09	AP1000	9/4/09	Turkey Point (2 units)	FL	Y
2009 TOTAL NUMBER OF APPLICATIONS = 1 TOTAL NUMBER OF UNITS = 2						
CY 2010–2012 Applications						
No COL applications returned in CY 2010–2012.						
2010–2012 TOTAL NUMBER OF APPLICATIONS = 0 TOTAL NUMBER OF UNITS = 0						
CY 2013 Applications						
Blue Castle Project		TBD		Utah (1 unit)	UT	N
AmerenUE		TBD		Calloway (1 unit)	MO	Y
2013 TOTAL NUMBER OF APPLICATIONS = 2 TOTAL NUMBER OF UNITS = 2						
CY 2014 Applications						
One COL application is expected in fourth quarter of CY 2014.						
2014 TOTAL NUMBER OF APPLICATIONS = 1 TOTAL NUMBER OF UNITS = 6						
2007–2014 TOTAL NUMBER OF APPLICATIONS = 23 TOTAL NUMBER OF UNITS = 296						

☐ – Accepted/Docketed ☐ – Expected ☐ – Approved

* Design technology was changed by the applicant on June 28, 2010.

Note: Application updates in this table do not show all projects previously mentioned because of changes in intent status or conversion to an ESP from a COL application. Data are shown as of June 30, 2012.

Figure 28. New Reactor Licensing Schedule of Applications by Design



Note: Lines depict approximate dates on schedule. Data on projected applications are based on information from potential applicants and are subject to change. Schedules depicted for future activities represent nominal assumed review durations based on submittal timeframes in letters of intent from prospective applicants. Numbers in ( ) next to the COL name indicate the number of units per site. The acceptance review is included at the beginning of the COL review. The rules in 10 CFR Part 2, "Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders," govern hearings on COLs.

On March 25, 2010, Exelon Nuclear Texas Holdings (Exelon) submitted an ESP application for the Victoria County Station site located in Victoria County, TX. Exelon previously submitted a COL application for the Victoria County Station site on September 2, 2008, and requested that the COL application be withdrawn when the NRC formally accepts the Victoria County Station ESP application.

On June 7, 2010, the NRC docketed the Victoria County ESP application. PSEG Power, LLC, and PSEG Nuclear, LLC (PSEG), submitted an ESP application in May 2010 on a site located near the Hope Creek/Salem site. The NRC expects to receive two additional ESP applications by the end of 2014.

Photo courtesy of Southern Company

Aerial view of Vogtle Units 3 and 4 construction site near Waynesboro, GA.

Design Certifications

The NRC has issued design certifications (DCs) for four reactor designs that can be referenced in an application for a nuclear power plant. A DC is valid for 15 years from the date of issuance, but it can be renewed for an additional 15 years. The new reactor designs incorporate new elements such as passive safety systems and simplified system designs.

These four designs are as follows:

- General Electric-Hitachi Nuclear Energy's (GEH's) Advanced Boiling-Water Reactor (ABWR)
- Westinghouse's System 80+
- Westinghouse's AP600
- Westinghouse's AP1000

The NRC is currently reviewing the following DC applications:

- AREVA's U.S. Evolutionary Power Reactor (EPR)
- Mitsubishi Heavy Industries' U.S. Advanced Pressurized-Water Reactor (US-APWR)

As of June 1, 2012, the NRC completed the technical reviews on GEH's Economic Simplified Boiling-Water Reactor (ESBWR).

In late 2011, the NRC completed rulemaking on Westinghouse's AP1000 DC amendment and STP Nuclear Operating Company's ABWR DC amendment to address the aircraft impact rule.

Design Certification Renewals

The NRC received two DC renewal applications for the ABWR from GEH and Toshiba in 2010. Renewals are good for 15 years.

Advanced Reactor Designs

A range of advanced reactor designs and technologies have emerged that may be submitted to the NRC within the next several years. These technologies include small-sized light-water reactors, liquid-metal reactors, and high-temperature gas-cooled reactors. The NRC will focus its advanced reactor efforts on ensuring that the agency is prepared to address the multiple new technologies being proposed. The NRC has been actively working to develop the regulatory framework in preparation for future licensing application submittals.

New Reactor Construction Inspections

The NRC established a special construction inspection organization in Region II in Atlanta, GA, to inspect licensee construction to ensure that it is performed in compliance with NRC-issued licenses and applicable regulations and to ensure that the as-built facility conforms to its COL. The NRC staff will examine the licensee's operational programs, such as security, radiation protection, and operator training and qualification, to ensure that the licensee is ready to operate the plant once it is built. The agency's construction site inspectors will verify a licensee's completion of inspections, tests, analyses, and acceptance criteria.

On February 10, 2012, the NRC issued a COL to Southern Nuclear Operating Company for Vogtle Units 3 and 4. On March 30, 2012, the NRC issued COLs to South Carolina Electric and Gas for V.C. Summer Units 2 and 3. The NRC provides oversight of the licensee and contractor activities under the Construction Reactor Oversight Process. This process periodically assesses licensee performance.

The NRC will use these direct inspections and other methods to confirm that the licensee has completed these actions and has met the acceptance criteria included in a COL before allowing startup of the plant.

The NRC has established resident inspector offices at both Vogtle and V.C. Summer. The inspectors will be at the site for the duration of the construction phase to oversee day-to-day activities of the licensee and its contractors. In addition, specialists in Region II's Center for Construction Inspection conduct periodic inspections at the site to ensure the facilities are being constructed in accordance with the approved design.

The agency also inspects vendor facilities to ensure that products and services furnished to new U.S. reactors meet quality and other regulatory requirements. The NRC has a vendor and quality assurance program and performs quality assurance inspections to ensure that licensees and their contractors meet the regulatory guidelines. To verify compliance with applicable regulations, the NRC inspects domestic and foreign vendors as well as the activities of applicants and licensees. More information on the NRC's new reactor licensing activities is available on the NRC Web site (see the Web Link Index).

Nuclear Regulatory Research

The NRC's research program supports the agency's regulatory mission by providing technical advice, tools, and information to identify and resolve safety issues, make regulatory decisions, and promulgate regulations and guidance. This includes conducting confirmatory experiments and analyses; developing technical bases that support the NRC's safety decisions; and preparing the agency for the future by evaluating the safety aspects of new technologies and designs for nuclear reactors, materials, waste, and security.

The research program focuses on challenges as the industry continues to evolve, including potential new safety issues, management of aging and material degradation issues, technical issues associated with the deployment of new technologies and reactor designs, and retention of technical skills as experienced staff retires. In the near term, research supports oversight of operating light-water reactors, the technology currently used in the United States. However, recent applications for advanced light-water reactors and preapplication activity regarding nonlight-water reactor vendors have prompted the agency to consider longer term research needs.

The NRC's research programs examine technical areas, such as:

- material degradation (e.g., stress-corrosion cracking, aging management, degradation mitigation technologies, boric acid corrosion, and embrittlement);
- new and evolving technologies (e.g., new reactor technology, mixed oxide fuel performance, digital instrumentation and control, and safety-critical software);
- experience gained from operating reactors;
- probabilistic risk assessment (PRA) methods;
- seismic and geotechnical hazards;
- ability of equipment to function in a harsh environment (e.g., heat, radiation, humidity);
- structural integrity assessments of reactor component degradation (e.g., nondestructive evaluation techniques and protocols); and
- human factors issues, including safety culture and computerization and automation of control rooms.

The research program also:

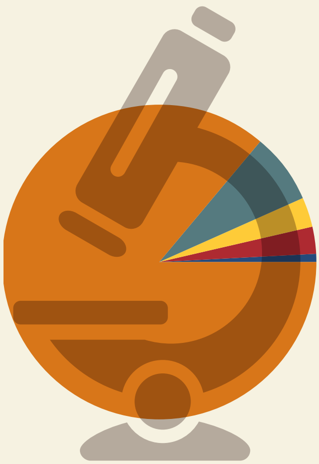
- Develops the agency's fire safety research programs, including fire modeling, fire PRA methods, and fire testing.
- Develops and improves computer codes as computational abilities expand and additional experimental and operational data allow for more realistic simulation. These computer codes analyze a wide spectrum of technical areas, including severe accidents, radionuclide transport through the environment, health effects of radioactive releases, nuclear criticality, fire conditions in nuclear facilities, thermal-hydraulic performance of reactors, reactor fuel performance, and nuclear power plant risk assessment.
- Ensures the secure use and management of nuclear facilities and radioactive materials by investigating potential security vulnerabilities and possible compensatory actions.

The NRC dedicates about 7 percent of its personnel and about 11 percent of its contracting funds to research. This research enables the NRC's highly skilled, experienced experts to formulate sound technical solutions based on science and to support timely and realistic regulatory decisions. The NRC research budget for FY 2012 is approximately $49.8 million. This includes contracts with national laboratories, universities, and other research organizations for greater expertise and access to research facilities. Figure 29 illustrates the primary areas of research. The NRC directs more than three-fourths of the research program toward maintaining the safety of existing operating reactors. The agency is also directing research in support of regulating new and advanced reactors. Radioactive waste programs and security are additional focus areas for research. Infrastructure support includes information technology and human resources. The NRC also has cooperative agreements with universities and nonprofit organizations to research specific areas of interest to the agency.

The NRC asked the National Academy of Sciences to assess the feasibility of doing a study on the cancer risk for populations around nuclear power facilities. The results of the scoping study (Phase 1 of the project) are publicly available and will be used to inform the epidemiological design of a potential Phase 2 cancer risk assessment.

See Appendix V for a list of cooperative agreements.

Figure 29. NRC Research Funding, FY 2012



Total $49.8 Million

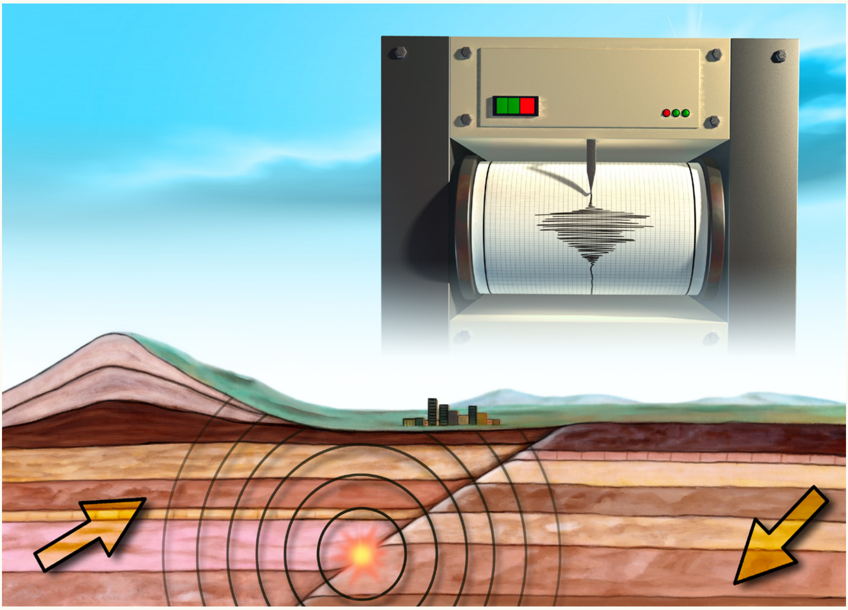
- Reactor Program—$42.8 M
- New/Advanced Reactor Licensing—$3.7 M
- Homeland Security—$1.5 M
- Materials and Waste—$1.3 M
- Infrastructure Support—$0.4 M

Note: Totals may not equal sum of components because of rounding.

Photo courtesy: University of Wisconsin–Madison

Universities and other academic institutions use nuclear materials in laboratory experiments and to provide health physics support to other institutional nuclear materials users.

Over the last decades, significant advances have been made in the ability to assess seismic hazards for nuclear power plants in the United States. The NRC is currently sponsoring several projects in support of both an updated assessment of seismic hazard in the Central and Eastern United States (CEUS) and an enhancement of the overall framework under which the hazard characterizations are developed. The NRC, in collaboration with several other government agencies, recently issued a new seismic source characterization (SSC) model and report for use in seismic hazard assessments for nuclear facilities in the CEUS. The SSC model, developed over 3 years, replaces seismic source models developed in the late 1980s and can be used to calculate the likelihood of various levels of earthquake-caused ground motions. The new SSC model will be used by licensed nuclear power plants in the CEUS for seismic reevaluations, in addition to being used for licensing new nuclear facilities.



The NRC requires all of its licensees to take seismic activity into account when designing and maintaining its nuclear power plants. When new seismic hazard information becomes available, the NRC evaluates the new data and models and determines if any changes are needed at plants.

The State-of-the-Art Reactor Consequence Analyses (SOARCA) research project has developed best estimates of the offsite radiological health consequences for potential severe accidents for two U.S. nuclear power plants: the Peach Bottom Atomic Power Station, a BWR near Delta, PA, and the Surry Power Station, a PWR near Surry, VA. The project, which began in 2007, combined up-to-date information about the plants' layout and operations with local population data and emergency preparedness plans. This information was then analyzed using state-of-the-art computer codes that incorporate decades of research into severe reactor accidents. The draft report describing the Peach Bottom and Surry analyses, NUREG-1935, "State-of-the-Art Reactor Consequence Analyses (SOARCA) Report: Draft Report for Comment," issued January 2012, is publicly available. Upon conclusion of the project, the methods and models developed for the severe accident analyses in the SOARCA program will continue to be used to inform other agency programs.

The NRC collaborates with the international research community on both light-water and nonlight-water reactor technologies. This collaboration enables the agency to better leverage its resources, to initiate activities focused on evolutionary advances in existing technologies, and to determine the safety implications of new technologies. Collaboration is aided by the agency's leadership role in the standing committees and senior advisory groups of international organizations, such as IAEA and NEA.

The NRC also has research agreements with foreign governments for international cooperative research. The NRC is engaged in over 100 cooperative research agreements with more than two dozen countries and NEA, covering technical areas from severe accident research and code development to materials degradation, nondestructive examination, and human factors research. The agreements let the NRC leverage its own research expenditures by greatly reducing the cost of conducting research independently. They also afford the NRC access to facilities capable of research not currently possible in the United States.

Examples of agreements include:

- the NRC's Program to Assess Reliability of Emerging Nondestructive Techniques, with Finland, Japan, South Korea, Sweden, and Switzerland;
- more than 20 agreements with foreign regulators and research organizations for participation in the NRC's Cooperative Severe Accidents Research Program.